



MicroTCA.4 in LLRF of BEPCII and HEPS

MA Xinpeng, GAN Nan, LU Chenyan , PENG Yongyi, SHAO Yanhua
on behalf of LLRF team

LINAC Group, Accelerator Division

Institute of High Energy Physics, Chinese Academy of Sciences

2021-08-25



Outline

1. MicroTCA.4 Background
2. LLRF of BEPCII Linac upgrade
3. LLRF of HEPS Linac
4. interoperability



1、 MicroTCA.4 Background

before 2019:

- ❑ MicroTCA.4 based LLRF started since ~2014;
- ❑ C-ADS Injector;
- ❑ BEPCII Linac SHB upgrade;

C-ADS (2014-2017)
Injector I - CM1/CM2



C-ADS (2016-2018)
- CM4



BEPCII Linac (2017-)
Sub-harmonic Bunchers



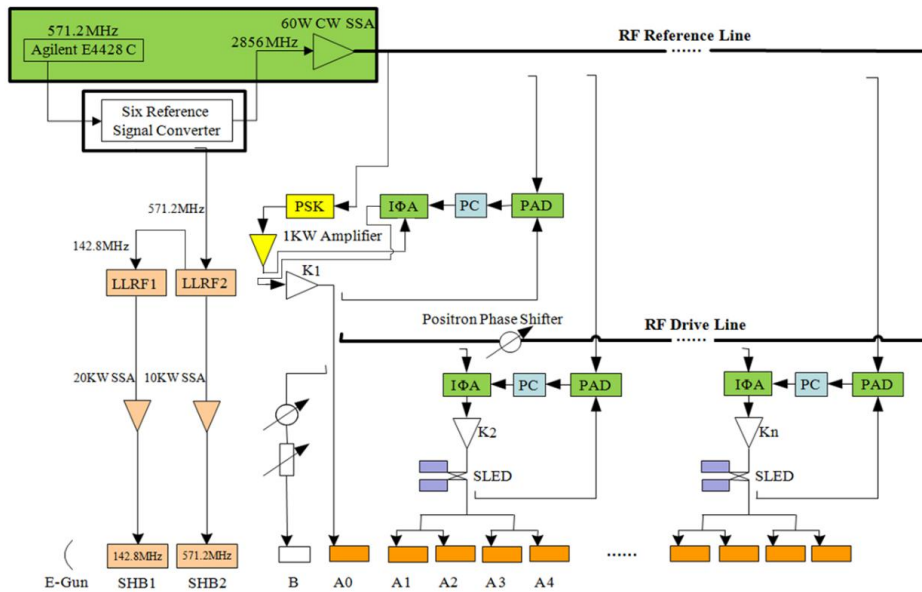
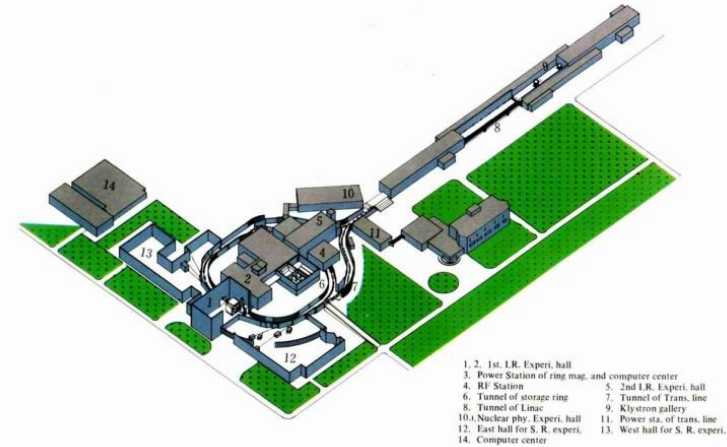


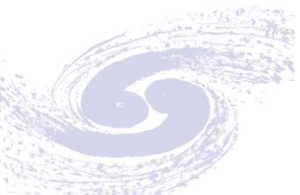
2、 LLRF upgrade of BEPCII Linac



LLRF upgrade of BEPCII Linac

- ❑ BEPCII: Beijing E-/E+ collider;
- ❑ 200m, 2856MHz/2.5GeV , 4us pulsed Linac
- ❑ 20 sets high power microwave source and accelerating tubes;
- ❑ **20 old phasing system (2006-)**





LLRF upgrade of BEPCII Linac



- Y19-20 upgrade 1
- Y20-21 upgrade 5

- Ref: 2856MHz ;
- Crate: ELMA-9U, PS: Wiener-1kW;
- MCH/CPU: NAT MCH-PHY80/RTM;
- SIS8300L2/DWC8VM1 from Struck;
- 8 ADC ; 2 DAC ;
- Timing: trigger through backplane;

2019.10

Signal dist.

Power meter

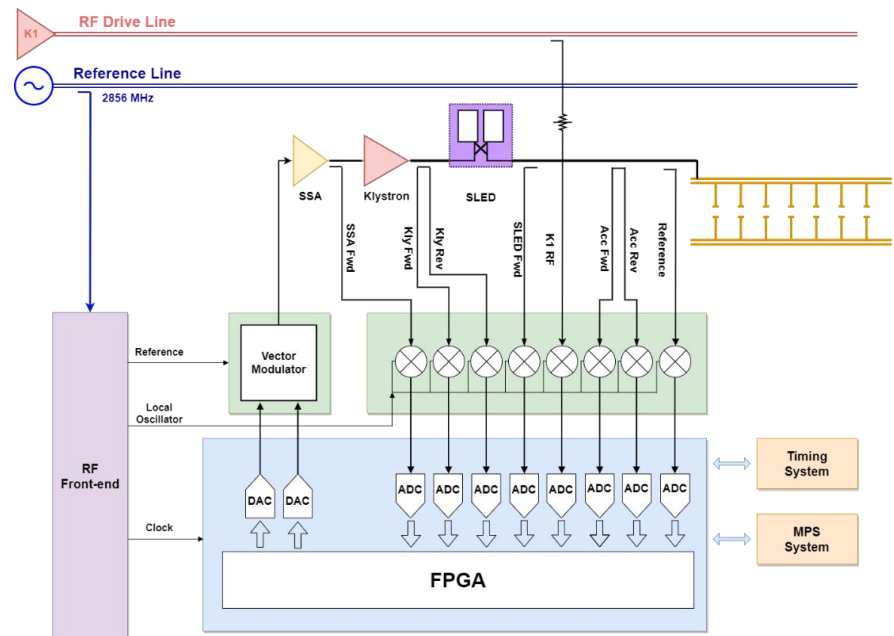
Monior

MicroTCA
Crate

RF front-end

1kW SSA

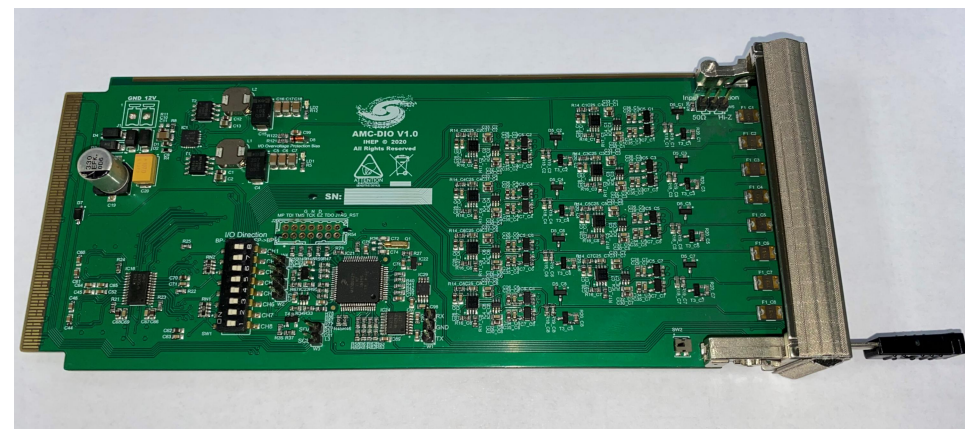
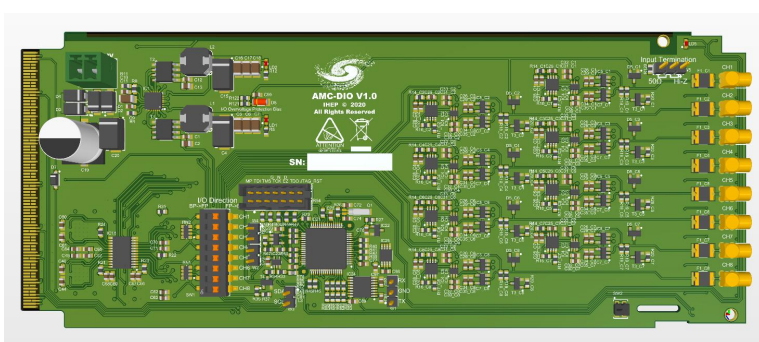
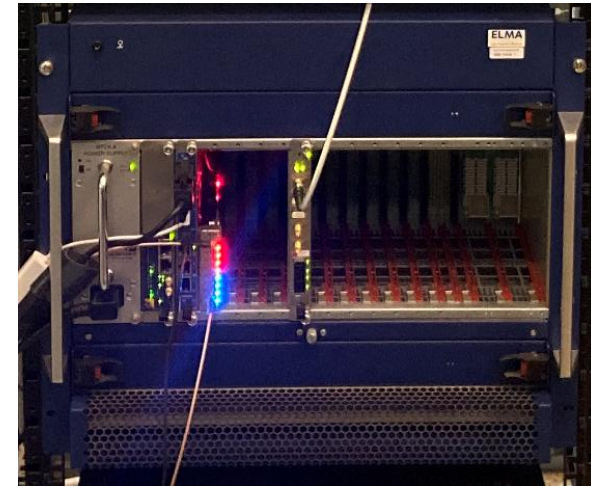
UPS





LLRF upgrade of BEPCII Linac

- ❑ **AMC board**
- ❑ Digital IO board for 8 channels timing trigger fanout;
- ❑ MMC took Samway solution;

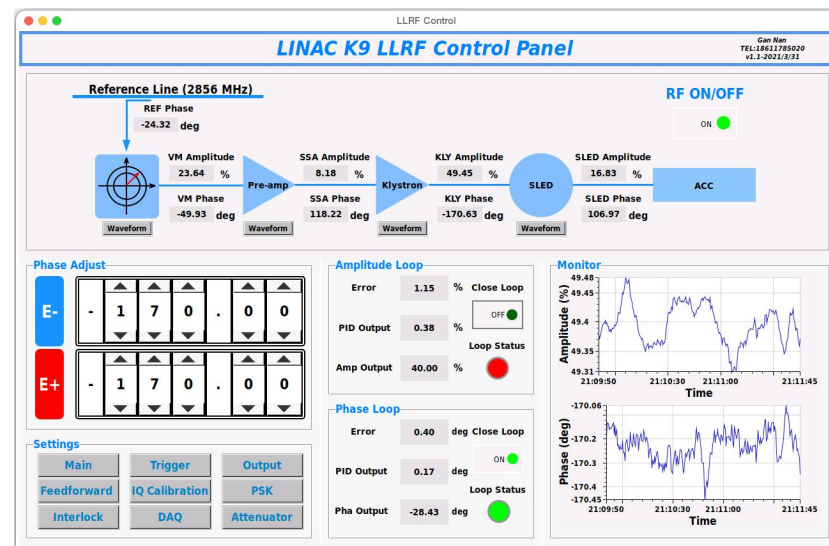


Courtesy by Gan Nan

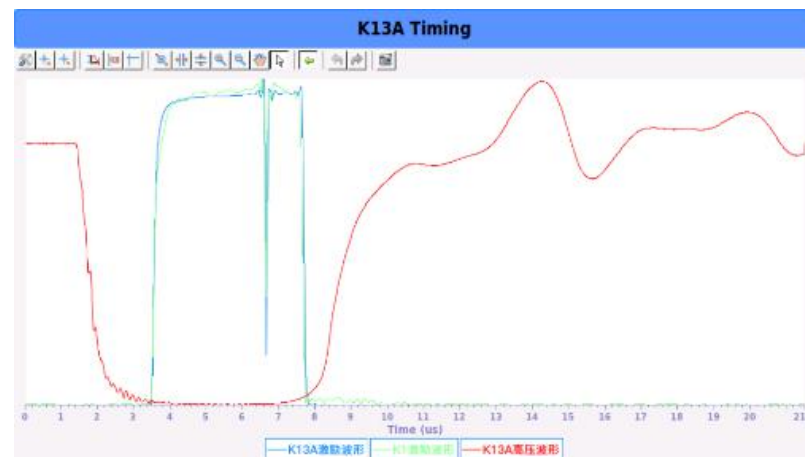
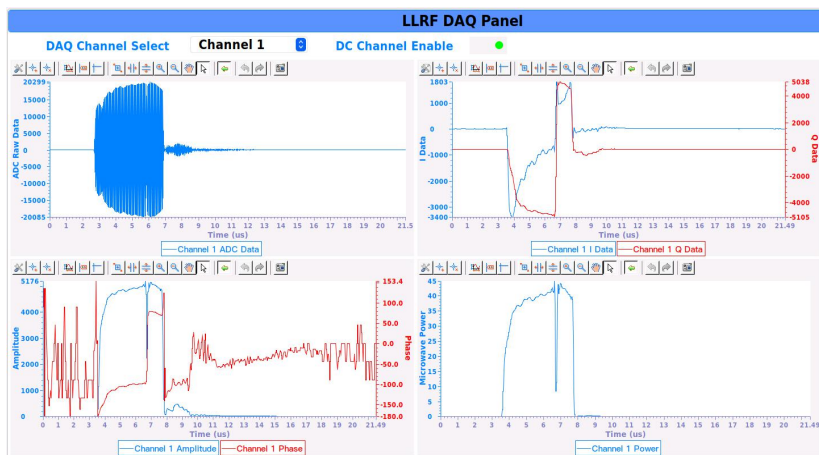


LLRF upgrade of BEPCII Linac

- downconvert 6 microwave signals AC coupled ;
- 1 Voltage/1 Current DC coupled ;
- monitoring high voltage and current of modulator:1) record perveance, 2) timing between HV and MW digitally;
- digital PSK ;
- support E+/E- switch;
- adjustable trigger of SSA/Mod/PSK;
- protection of klystron by reverse power;
- feedforward;
- I/Q cali
- interlock



short-term stability: amp:1%(p-p) , phase:0.5deg(pp)



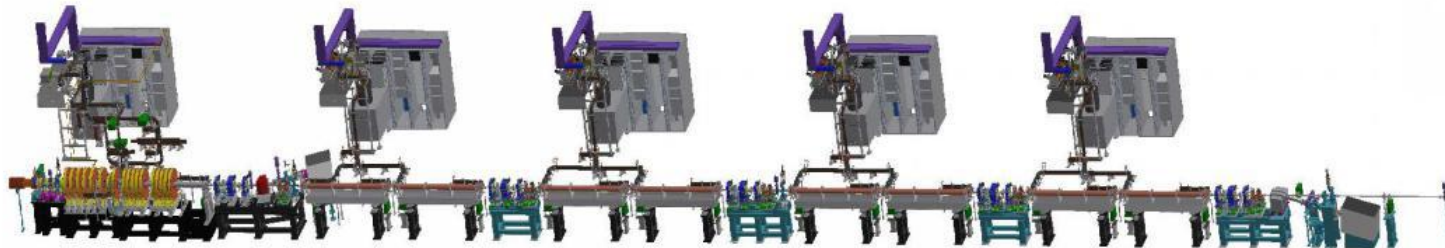
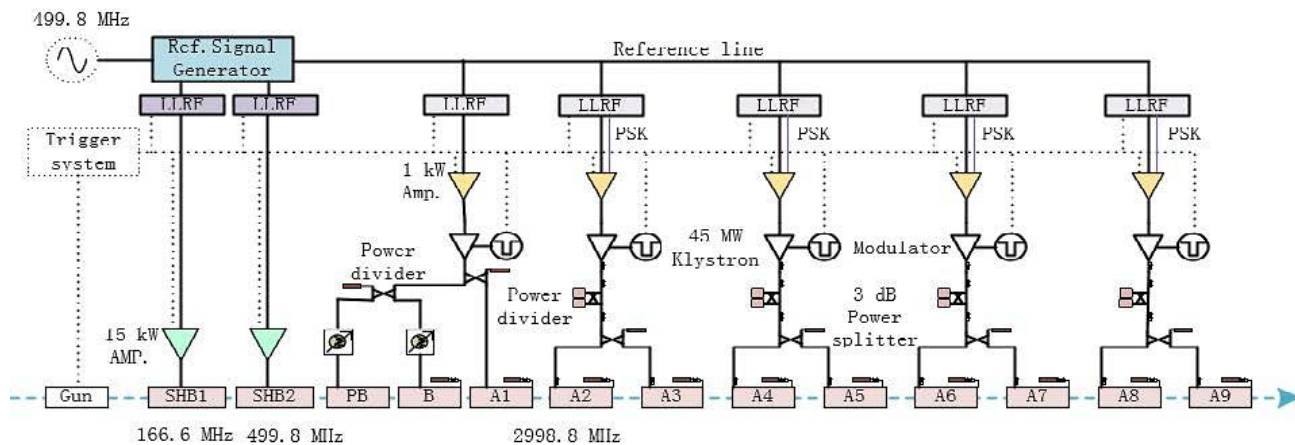


3、 LLRF of HEPS Linac



LLRF of HEPS Linac

- 5 sets 2998.8MHz pulsed klystron and accelerating tubes; ~BEP CII Linac;
- 166.6MHz Sub Harmonic Buncher SHB1 and 499.8MHz SHB2;



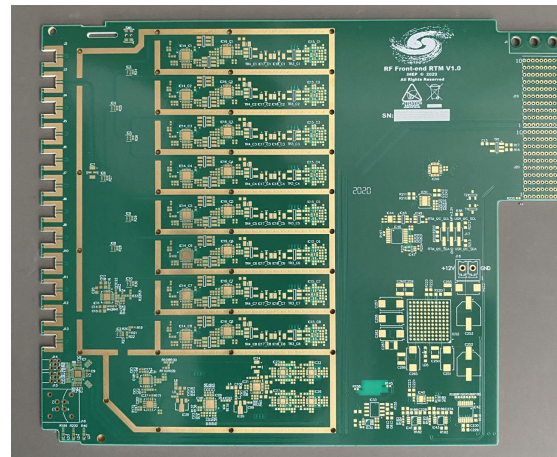
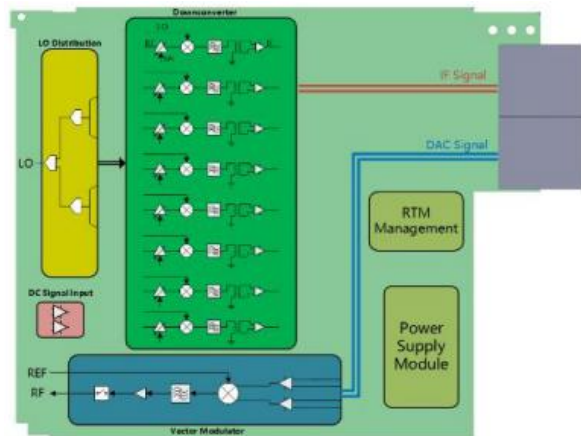


LLRF of HEPS Linac

❑ Downconverter RTM board

- ❑ Input bandwidth: 300MHz-6GHz ;
- ❑ 8 ADCs ; 2 DACs ;
- ❑ Input: RF, LO, ;

preliminary under full test

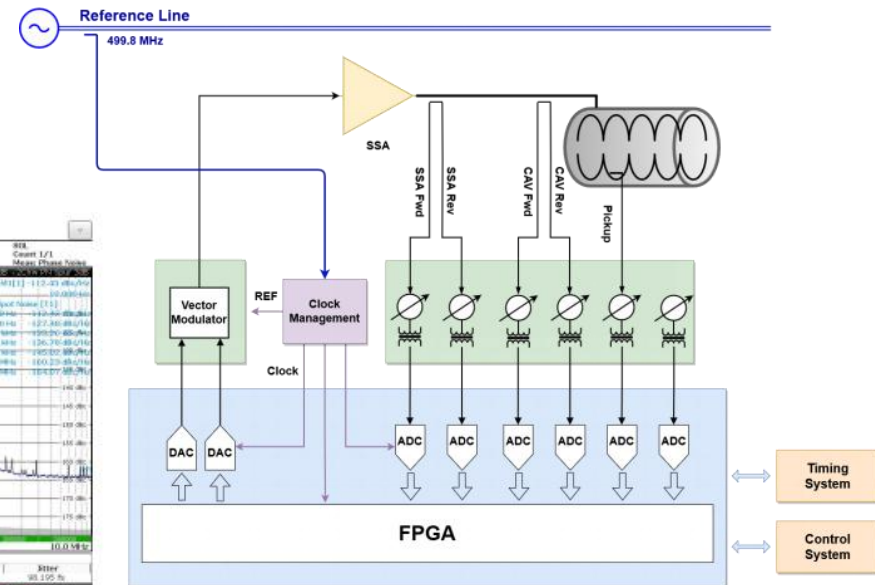
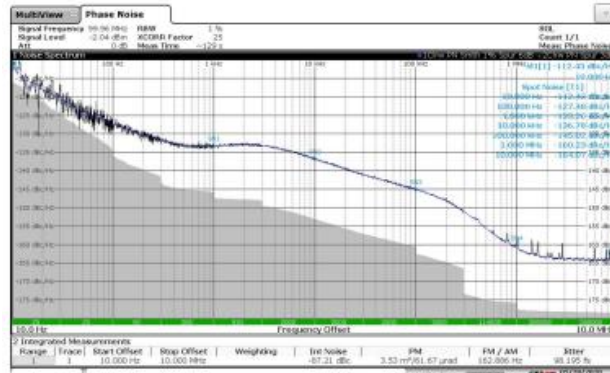
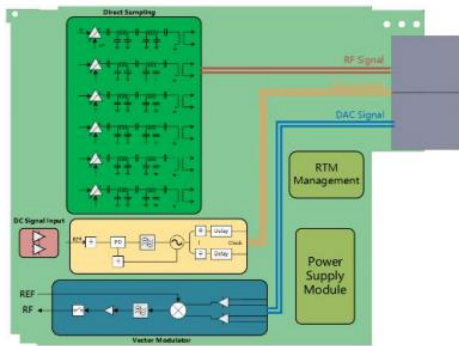


Courtesy by Gan Nan



LLRF of HEPS Linac

- ❑ Direct sampling RTM board
- ❑ Input bandwidth: 0-650MHz ;
- ❑ 99.96MHz clock jitter: 98fs (10Hz-10MHz) ;
- ❑ 6 ADC , 2DAC ;
- ❑ for 2 SHB bunchers LLRF;



Courtesy by Gan Nan



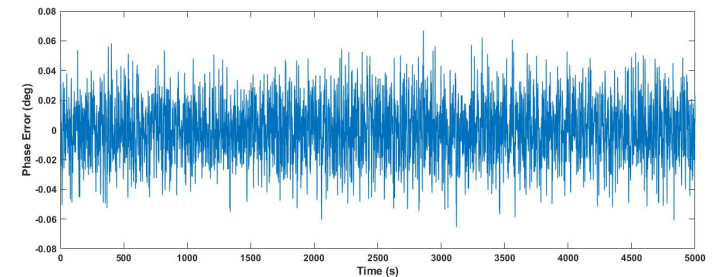
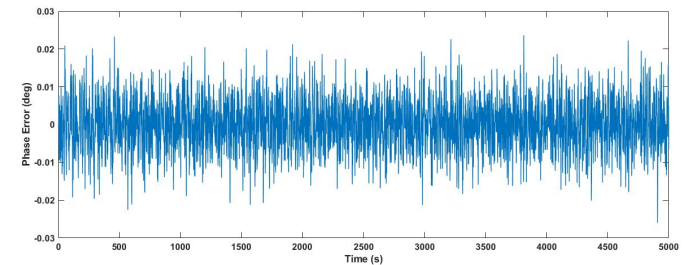
LLRF of HEPS Linac

preliminary tested with Struck SIS8300L2

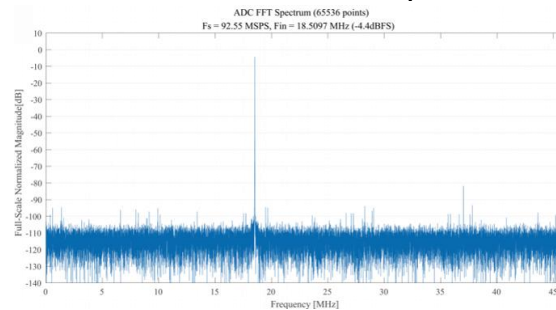


166MHz DS
P-P Err < $\pm 0.02^\circ$
RMS Err = 0.007°

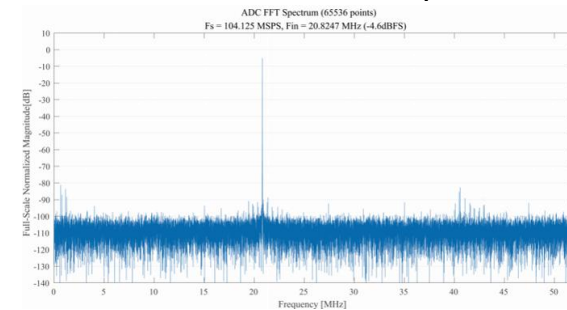
499MHz DS
P-P Err < $\pm 0.07^\circ$
RMS Err = 0.019°



166.6MHz direct sampled



499.8MHz direct sampled



Courtesy by Gan Nan

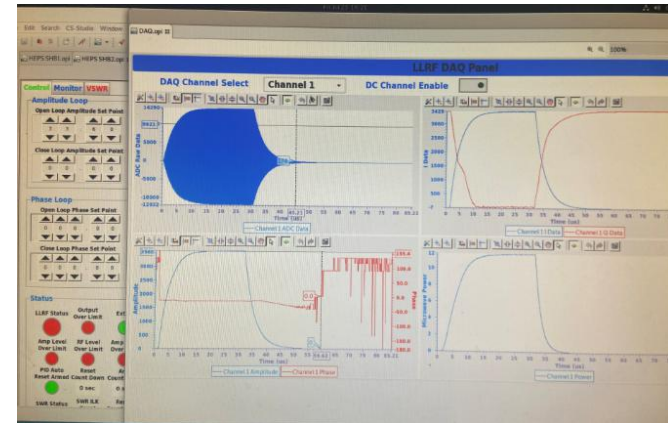
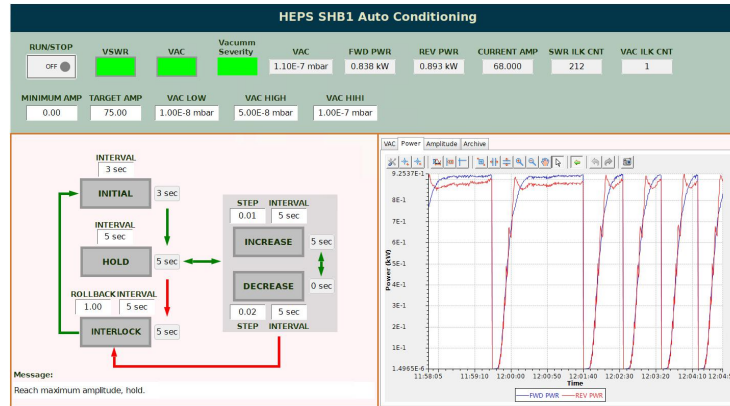
SFDR better than 80dB



LLRF of HEPS Linac

DS RTM on HEPS SHB TB @166.6/499.8MHz

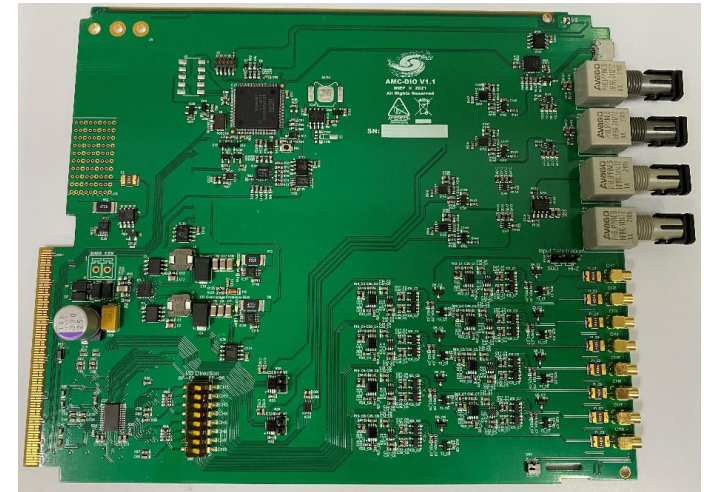
DWC RTM on HEPS TB @2998.8MHz





LLRF of HEPS Linac

- Timing/interlock fanout board
- using openmmc;
- work well with NAT MCH;
- 8 electro-I/Os & 4 optical-I/Os to backplane MLVDS



MMC with basic functions based on OpenMMC
 FRU, HOTSWAP, PAYLOAD, SDR(TEMP, VOLTAGE, CURRENT), GPIO

```

nat> show_sensorinfo 8
Sensor Information for FRU 8 / AMC4
=====
#   SDRType  Sensor Entity Inst  Value  State  Name
-----
-   MDevLoc   0xc1  0x64
1   Compact  0xf2  0xc1  0x64  0x01   HOTSWAP AMC
2   Full     Voltage 0xc1  0x64  3.280 V  ok    AMC +3.3V
3   Full     Voltage 0xc1  0x64  4.984 V  ok    AMC +5.0V
4   Full     Voltage 0xc1  0x64  0.000 V  <=lnr  RTM +12V
5   Full     Current 0xc1  0x64  1.824 A  ok    AMC +3.3V Curr
6   Full     Current 0xc1  0x64  0.800 A  ok    AMC +5.0V Curr
7   Full     Current 0xc1  0x64  0.000 A  ok    RTM +12V Curr
8   Full     Temp    0xc1  0x64  27.5 C   ok    TEMP 1
9   Full     Temp    0xc1  0x64  30.5 C   ok    TEMP 2
10  Full     Temp    0xc1  0x64  27.5 C   ok    TEMP 3
11  Full     Temp    0xc1  0x64  28.5 C   ok    TEMP 4
12  Compact  0xf0  0xc1  0x64  0x10    HS 008 AMC4
=====
  
```

```

nat>show_fruinfo 8
-----
FRU Info for device 8:
-----
Common Header   : 0x01 0x00 0x00 0x01 0x07 0x10 0x00 0xe7
Internal Use Area : -
-----
Chassis Info Area : -
-----
Board Info Area   : at offs=8, len=48
Manufacturer(05)  : IHEP
Board Name(08)    : AMC-DIO
Serial Number(10) : SN:000000
Part Number(04)   : DIO
FRU file ID(08)   : DIO-FRU
-----
Product Info Area : at offs=56, len=72
Manufacturer(05)   : IHEP
Product Name(08)  : AMC DIO
Product Number(08): DIO-1.0
Part Version(04)  : 1.0
Product Serial Number(10): SN:000000
Asset Tag(12)     : Generic FRU
FRU file ID(08)   : DIO-FRU
-----
  
```

Courtesy by Gan Nan



LLRF of HEPS Linac

- **Crates** has been produced in China:
- **ELMA 9U**: 5 working on BEPCII Linac
- backplane is provided by ELMA@Germany, others re-design/in-production in China
- first delivery, test with the vendor using our boards;
- basic functions are OK, mechanical, assembling, wiring and engineering need improving in future.





LLRF of HEPS Linac

- ❑ **Crates** has been produced in China:
- ❑ **nVent 3U/9U:**
- ❑ 3U/9U are made in nVent China factory, has been delivered and tested at LLRF and timing systems;
- ❑ basic function OK with other boards; quite the same with the one made in Europe.



9U tested for HEPS timing system
Courtesy by LIU Fang





LLRF of HEPS Linac

- ❑ **Crates** has been produced in China:
- ❑ **Yuanzhong 10U**: 1.5kW integrated PS
- ❑ work at BEPCII Linac over 6 months, function is OK.
- ❑ an optimized version is under test

LI Rui, MicroTCA system engineering, developing and domestic production. This workshop





LLRF of HEPS Linac

□ MicroTCA.4 based LLRF system running:

x6 running
on BEPCII
Linac

3 running on testbench for HPMW
conditioning and test

1 running
for SC on
PAPS

1 running
for RefLine
test





4、 interoperability



interoperability

❑ Vadatech MCH (UTC002):

- abnormal with DESY MMC(Struck), can't power-up;
- MCMC version <V2.8.0/2015 normal with Struck mmc/openmmc





Thank you for your attention!